CSCI500: Foundations of Advanced Computer Science

Course Summary

Course: CSCI500 Title: Foundations of Advanced Computer Science

Length of Course: 8 weeks

Prerequisites: Admission to MS program or chair's approval **Credit Hours:** 3

Description

Course Description:

This course serves as an essential primer for students in computer science, providing the foundations for advanced computer science study and subsequent work in CSCI 505, CSCI 510, and CSCI 520. It develops core knowledge and skills in data structures, algorithms, machine learning, and big data analytics. Emphasis is placed on applying theory to computational systems and software development challenges, while introducing techniques that support deeper understanding of advanced computational problems, machine learning, artificial intelligence, and big data analytics. The course also highlights connections to engineering concepts and professional practice within the field. These elements strengthen the subject's foundations and align with program outcomes, ensuring students have the resources needed for progression within the Master of Computer Science degree.

Course Scope:

The course will provide the knowledge and skills necessary to excel in the rapidly evolving fields of machine learning, artificial intelligence, and big data analytics. Through a combination of theoretical instruction and practical application, tools, and frameworks, students will be prepared to tackle the challenges of their subsequent studies. This course will ensure that students are competent and ready to take the advanced courses in the Master of Computer Science program. This course is a prerequisite for CSCI 505, CSCI 510, and CSCI 520.

Objectives

By the end of this course, you will be able to:

- CO-1: Explain data structures and algorithms for solving complex computational problems.
- CO-2: Examine theoretical principles, methodologies, and applications of machine learning (ML) and artificial intelligence (AI).
- CO-3: Apply big data analytics and data mining techniques to real-world applications.
- CO-4: Apply algorithmic design paradigms to solve complex computational problems.
- CO-5: Apply Python libraries and other high-level languages to explore computational problems, ML, and AI.
- CO-6: Discuss the ethical implications and societal impacts of AI technologies.
- CO-7: Explain advanced data structures, machine learning, and big data analytics coursework.
- CO-8: Develop a paper and presentation through written and oral presentations on your selected topic.

Outline

Week 1: Data Structures and Algorithms: Fundamentals and Basic Structures

Learning Objectives

- CO-1: Explain data structures and algorithms for solving complex computational problems.
    - LO-1.1: Identify the role of data structures in efficient problem-solving.
    - LO-1.2: Categorize various types of data structures including arrays, linked lists, stacks, and queues.
    - LO-1.3: Calculate time and space complexity of fundamental algorithms.
    - LO-1.4: Code basic operations on arrays, linked lists, stacks, and queues using Python.

Reading and Resources

Links for all readings are provided in the course e-Reserve. This is in each of the weekly lessons under the heading Readings & Resources.

Assignments

- Week 1 Welcome Discussion -- For week 1, the discussion is due at the end of the week on Sunday. In subsequent weeks, the initial post is due mid-week.

- Week 1 Discussion: Efficiency in Data Structures

Week 2: Data Structures and Algorithms: Trees, Sorting and Graph Algorithms

Learning Objectives

- CO-1: Explain data structures and algorithms for solving complex computational problems.
    - LO-1.5: Differentiate between various types of trees as hierarchical data structures.
    - LO-1.6: Construct basic tree operations like insertion, deletion, and traversal.
    - LO-1.7: Evaluate time complexity of tree operations and their applications.
    - LO-1.8: Compare graph traversal algorithms like BFS and DFS and their use cases.
    - LO-1.9: Analyze time and space complexities of various sorting algorithms.

- CO-4: Apply algorithmic design paradigms to solve complex computational problems.
    - LO-4.1: Implement Dijkstra's algorithm for finding the shortest path in a graph.

- CO-5: Apply Python libraries and other high-level languages to explore computational problems, ML, and AI.
    - LO-5.1: Code sorting algorithms using Python.

Reading and Resources

Links for all readings are provided in the course e-Reserve. This is in each of the weekly lessons under the heading Readings & Resources.

Assignments

- Week 2 Discussion: Tree and Graph Algorithm Applications
- Week 2 Assignment: Critical Assignment Challenge 2

Week 3: Algorithmic Design Paradigms: Divide and Conquer, Dynamic Programming, and Greedy Algorithms

Learning Objectives

- CO-4: Apply algorithmic design paradigms to solve complex computational problems.
    - LO-4.2: Define algorithmic design paradigms as general approaches to problem-solving.
    - LO-4.3: Distinguish between divide and conquer, dynamic programming, and greedy algorithms.

    - LO-4.4: Calculate time and space complexity of algorithms using these paradigms.
    - LO-4.5: Apply divide and conquer to problems like merge sort and quick sort.
    - LO-4.6: Solve knapsack and longest common subsequence problems using dynamic programming.
    - LO-4.7: Implement activity selection and Huffman coding using greedy algorithms.

- CO-5: Apply Python libraries and other high-level languages to explore computational problems, ML, and AI
    - LO-5.2: Code algorithms using divide and conquer, dynamic programming, and greedy approaches.

Reading and Resources

Links for all readings are provided in the course e-Reserve. This is in each of the weekly lessons under the heading Readings & Resources.

Assignments

- Week 3 Discussion: Comparing Algorithmic Design Paradigms

Week 4: Introduction to Machine Learning and AI

Learning Objectives

- CO-2: Examine theoretical principles, methodologies, and applications of machine learning (ML) and artificial intelligence (AI).
    - LO-2.1: Define machine learning as a subfield of AI focusing on data-learning algorithms.
    - LO-2.2: Differentiate between supervised, unsupervised, and reinforcement learning.
    - LO-2.3: Describe supervised learning algorithms including regression and decision trees.
    - LO-2.4: Analyze unsupervised learning algorithms including clustering and dimensionality reduction.
    - LO-2.5: Evaluate the role of feature engineering on model performance.
- CO-5: Apply Python libraries and other high-level languages to explore computational problems, ML, and AI.
    - LO-5.3: Implement basic ML models using Python libraries.
- CO6. Discuss the ethical implications and societal impacts of AI technologies.
    - LO-6.1: Identify ethical considerations and potential biases in AI applications.

Reading and Resources

Links for all readings are provided in the course e-Reserve. This is in each of the weekly lessons under the heading Readings & Resources.

Assignments

- Week 4 Discussion: Ethical Considerations in AI
- Week 4 Assignment: Critical Assignment Challenge 3

Week 5: Advanced Machine Learning Techniques: Deep Learning and Neural Networks

Learning Objectives

- CO-2: Examine theoretical principles, methodologies, and applications of machine learning (ML) and artificial intelligence (AI).
    - LO-2.6: Describe the fundamentals of deep learning and its domain applications.
    - LO-2.7: Analyze CNN architecture and functionality for image processing tasks.
    - LO-2.8: Examine RNN architecture and functionality for sequence modeling tasks.
    - LO-2.9: Apply regularization strategies for addressing overfitting and underfitting.
    - LO-2.10: Evaluate advanced techniques like transfer learning and ensemble methods.

- CO-5: Apply Python libraries and other high-level languages to explore computational problems, ML, and AI.
    - LO-5.4: Construct deep learning models using Python libraries.

Reading and Resources

Links for all readings are provided in the course e-Reserve. This is in each of the weekly lessons under the heading Readings & Resources.

Assignments

- Week 5 Discussion: Challenges in Neural Network Training

Week 6: Introduction to Big Data Analytics and Data Mining

Learning Objectives

- CO-3: Apply big data analytics and data mining techniques to real-world applications.
    - LO-3.1: Characterize big data using its key attributes.
    - LO-3.2: Assess challenges and opportunities presented by big data.
    - LO-3.3: Demonstrate data preprocessing and feature engineering techniques.
    - LO-3.4: Compare data mining techniques for classification, clustering, and anomaly detection.

    - LO-3.5: Explain pattern recognition and predictive modeling applications.

- CO-5: Apply Python libraries and other high-level languages to explore computational problems, ML, and AI.
    - LO-5.5: Analyze big datasets using Python libraries and tools.

Reading and Resources

Links for all readings are provided in the course e-Reserve. This is in each of the weekly lessons under the heading Readings & Resources.

Assignments

- Week 6 Discussion: Techniques for Big Data Analysis
- Week 6 Assignment: Critical Assignment Challenge

Week 7: Programming Tools and Frameworks for ML, AI, and Big Data Analytics

Learning Objectives

- CO-5: Apply Python libraries and other high-level languages to explore computational problems, ML, and AI.
    - LO-5.6: Compare programming languages and frameworks for ML and data analytics.
    - LO-5.7: Develop ML and AI models using Python libraries.
    - LO-5.8: Utilize cloud-based platforms for big data processing.
    - LO-5.9: Apply version control systems for collaborative development.
    - LO-5.10: Create data visualizations for communicating project findings.

Reading and Resources

Links for all readings are provided in the course e-Reserve. This is in each of the weekly lessons under the heading Readings & Resources.

Assignments

- Week 7 Discussion: Comparing ML and Big Data Frameworks

Week 8: Capstone Project and Course Wrap-up

Learning Objectives

- CO-7: Explain advanced data structures, machine learning, and big data analytics coursework.
    - LO-7.1: Integrate knowledge across data structures, algorithms, ML, and big data analytics.

- CO-8: Develop a paper and presentation through written and oral presentations on your selected topic.
    - LO-8.1: Complete a clear and concise oral presentation on a selected topic.
    - LO-8.2: Develop a well-structured research paper summarizing the chosen topic.
    - LO-8.3: Assess peer presentations and papers through constructive feedback.

Reading and Resources

Links for all readings are provided in the course e-Reserve. This is in each of the weekly lessons under the heading Readings & Resources.

Assignments

- Week 8 Discussion: Synthesis for Advanced Graduate Studies
- Week 8 Capstone Project Submission

Evaluation

Late Assignments

Students are expected to submit assignments by the due dates listed in the classroom. Late assignments, including but not limited to Assignments, Discussions, posts and responses, quizzes, and exams, may or may not be accepted after the course end date. Submitting an assignment after the due date may result in a penalty of up to 10% of the grade per day late, not to exceed a maximum 50% of the grade. The amount of the penalty is at the faculty member's discretion. Faculty recognize that students have limited time and maybe more flexible if potential delays are communicated ahead of time.*

*Doctoral and Programs with specialty accreditation may have different late policies.

**Students with DSA accommodations may have different late policies applied. For more information regarding our DSA services, please contact DSA@apus.edu.

Grading

- **Discussions 30%**
  - Eight weekly discussions, each worth 100 points
- **Assignments 50%**
  - Three critical assignments, each worth 100 points
- **Final Project 20%**
  - Written paper and presentation

Materials

Book Title: Various resources from Trefry Library and/or the Open Web are used. Links are provided inside the classroom.

All required readings are located in the Reading and Resources tab under the Lessons tab.

Course Guidelines

Writing Expectations

All activities completed in this course are to follow the stated instructions (inside the classroom). Always check the grading rubrics to see what your instructor will be on the lookout for when grading your work. Also, be sure you have read the APUS Plagiarism Policy (the entire Academic Dishonesty section) before submitting work in this or in any other course. See the above Course Outline or the Policies section on this Syllabus for links.

Citation and Reference Style

Attention: You will follow the citation style that is common to your discipline. Instructions regarding citation styles are included in the classroom.

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Also, completing all Assignments (under the Assignments tab) is paramount to your success in this course.

Netiquette

Online universities promote the advancement of knowledge through positive and constructive debate, both inside and outside the classroom. Forums on the Internet, however, can occasionally degenerate into needless insults and flaming. Such activity and the loss of good manners are not acceptable in a university setting. Basic academic rules of good behavior and proper Netiquette must persist. Remember that you are in a place for the rewards and excitement of learning, which does not include descent to personal attacks or student attempts to stifle the learning of others.

- Humor Note: Despite the best of intentions, jokes and especially satire can easily get lost or taken seriously. If you feel the need for humor, you may wish to add emoticons to help alert your readers: ;-), :), .

Disclaimer Statement

Course content may vary from the outline to meet the needs of this particular group.

Communications

Student Communication

To reach the instructor, please communicate through the MyClassroom email function accessible from the Classlist of the Course Tools menu, where the instructor and students email addresses are listed, or via the Office 365 tool on the Course homepage.

- In emails to instructors, it is important to note the specific course in which you are enrolled. The name of the course is at the top center of all the pages.
- Students and instructors communicate in Discussion posts and other learning activities.
- All interactions should follow APUS guidelines, as noted in the Student Handbook, and maintain a professional, courteous tone.

- Students should review writing for spelling and grammar.
- Tips on Using the Office 365 Email Tool

Instructor Communication

The instructor will post announcements on communications preferences involving email and Instant Messaging and any changes in the class schedule or activities.

- Instructors will periodically post information on the expectations of students and will provide feedback on assignments, Discussion posts, quizzes, and exams.
- Instructors will generally acknowledge student communications within 24 hours and respond within 48 hours, except in unusual circumstances (e.g., illness).
- The APUS standard for grading all assessments (assignments, Discussions, quizzes, exams) is five days or fewer from the due date.
- Final course grades are submitted by faculty no later than seven days after the end date of the course or the end of the extension period.

University Policies

Consult the Student Handbook for processes and policies at APUS. Notable policies:

- Drop/Withdrawal Policy
- Extension Requests
- Academic Probation
- Appeals
- Academic Dishonesty / Plagiarism
- Disability Accommodations
- Student Deadlines
- Video Conference Policy

Mission

The mission of American Public University System is to provide high-quality higher education with emphasis on educating the nation's military and public service communities by offering respected, relevant, accessible, affordable, and student-focused online programs that prepare students for service and leadership in a diverse, global society.

Minimum Technology Requirements

- Please consult the catalog for the minimum hardware and software required for undergraduate and graduate courses.

- Although students are encouraged to use the Pulse mobile app with any course, please note that not all course work can be completed via a mobile device.

Disclaimers

- Please note that course content -- and, thus, the syllabus -- may change between when a student registers for a course and when the course starts.
- Course content may vary from the syllabus' schedule to meet the needs of a particular group.